

# ABSTRACT

This invention describes new developments in Sagnac Raman amplifiers and cascade lasers to improve their performance. The Raman amplifier bandwidth is broadened by using a broadband pump or by combining a cladding-pumped  
5 fiber laser with the Sagnac Raman cavity. The broader bandwidth is also obtained by eliminating the need for polarization controllers in the Sagnac cavity by using an all polarization maintaining configuration, or at least using loop mirrors that maintain polarization. The polarization maintaining cavities have the added benefit of being  
10 environmentally stable and appropriate for turn-key operation. The noise arising from sources such as double Rayleigh scattering is reduced by using the Sagnac cavity in combination with a polarization diversity pumping scheme, where the pump is split along two axes of the fiber. This also leads to gain for the signal that is independent of the  
15 signal polarization. Finally, a two-wavelength amplifier for 1310 nm and 1550 nm can be implemented by using a parallel combination of Raman amplifiers with shared pump lasers or by combining Raman amplifiers with erbium-doped fiber amplifiers. Combinations of the above improvements can be used advantageously to meet specifications for broad  
20 bandwidth, polarization independence, noise performance and multi-wavelength operation.

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